Exhibit 9

Providence Photonics, *Shell Monaca FlareGuardian™ Field Study—Final Report* (Jan. 2023).

PROVIDENCE PHOTONICS

Shell Monaca FlareGuardian™ Field Study

Final Report | Revision 1.0

January 2023

PROJECT 0005-008

SHELL MONACA

PREPARED BY
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Introduction

Zeeco Inc (Zeeco) retained Providence Photonics, LLC (Providence) to conduct performance measurements with the FlareGuardian at Shell Polymer's Monaca (SPM) facility in Beaver County, Pennsylvania. The FlareGuardian was installed on January 12th, 2023 and removed on January 20th, 2023. This report summarizes the FlareGuardian results.

Background

The FlareGuardian utilizes a multi-spectral midwave infrared imager to measure relative concentrations of combustion gases. The method was designed to be a continuous and autonomous remote flare monitor and can be integrated in the plant control system. In this instance, the FlareGuardian was not tied to the plant systems but the data was recorded locally and retrieved manually for reporting purposes.

The FlareGuardian was installed to view the northern most Enclosed Ground Flare. It was installed near Furnace 5 at an elevation about the same as the top of the flare enclosure. The distance from the FlareGuardian to the flare enclosure was 130 meters.

There were two flare tests conducted, one on January 13th, 2023 and another on January 19th, 2023. Another unplanned flaring event occurred on January 20th, 2023. The FlareGuardian was designed to monitor an elevated flare. It can be used to measure an enclosed flare (where the flame is not visible) provided the temperature of the post combustion gas is above 400°C as it exits the enclosure. This temperature threshold was achieved during both of the flare tests and the flaring event.

Results

The results from FlareGuardian measurements are tabulated in **Appendix A** and a summary is provided in ***Table 1***.

Date	Start Time (Local)	End Time (Local)	Process Condition	CE Avg (%)	DRE Avg (%)	SI Avg	FF Avg (m2)	FH Avg (MMBTU/HR)
1/13/2023	1:45 PM	1:53 PM	Flare test - Methane/Hydrogen	97.39	98.24	0.7	187	0.31
1/19/2023	11:25 AM	12:23 PM	Flare test - Ethane/Methane	98.93	99.55	0.7	195	0.49
1/20/2023	8:03 AM	9:02 AM	Flaring event	99.01	99.62	1.2	150	0.21

Table 1: Summary FlareGuardian Results.

Flare Performance Metrics

The Mantis flare monitor provides five flare performance metrics at a 1-second data interval. The methane emission rate (sixth metric) is derived from the Mantis measurements and process data provided by the facility. The descriptions of these metrics are provided below:

1. COMBUSTION EFFICIENCY (0 TO 100%): Combustion efficiency (CE) is a measure of the relative concentration of hydrocarbon vs. carbon dioxide in the post combustion gas plume. If there is no hydrocarbon present in the post combustion gas plume, then CE is 100%. CE should not be confused with Destruction and Removal Efficiency (DRE). The

difference between these two metrics is discussed in **Appendix C**. While CE is directly measured by the VISR method, DRE is derived using correlations established through extractive sampling as discussed in **Appendix C**.

2. SMOKE INDEX (0 TO 10): Smoke index (SI) is a unit-less number which indicates the degree of visible emissions within the combustion envelope. A SI of 0 means no visible emissions are present while a SI of 10 means the flare has heavy black smoke. While SI only represents the degree of visible emissions within the combustion envelope, it is generally correlated to opacity and a SI above 3 generally indicates that some visible emissions are likely present outside of the combustion envelope.
3. FLAME FOOTPRINT (M^2): Flame footprint (FF) is a measure of the flame size in square meters. It is not necessarily correlated to the visible flame size as the FF is determined by the radiance, not the visible flame. Note that the orientation of the flame will impact the FF as the depth of the flame will change with viewing angle.
4. FRACTIONAL HEAT RELEASE (BTU/HR): Fractional Heat Release (FH) is a measure of the heat released from flare combustion in the spectral bands monitored by the Mantis flare monitor. Although it is not a measure of the total heat release across the entire energy spectrum, FH is expected to be correlated to the total heat release.
5. FLAME STABILITY (0 TO 100%): Flame stability (FS) is a measure of the change in radiance measured by the Mantis flare monitor in a 1-second interval. A FS of 100% indicates a flame that has a constant radiance. A low FS value (generally lower than 80%) indicates a flame with significant radiance fluctuation within 1 second interval, suggesting a less stable flame. Variability on a longer time scale will not be described by the flame stability metric.

Data Quality Indicators

The VISR method has two important data quality indicators (DQI) to assess the quality of the measurement. The first is the number of pixels in the flame combustion envelope, the outer layer of the flame where the combustion process has ceased. The VISR method requires at least 30 pixels to accurately determine the performance metrics of the flame. The VISR device has a fixed focal length, so the number of pixels in the flame is determined by the size of the flame and the distance from the VISR imager to the flame. For this study, any measurements with less than 30 pixels were removed from the summary tables and **Appendix A**.

The second important DQI is the Smoke Index level. As the smoke index increases above 3.0 (this threshold may vary within a range of 1-2 depending on specific flares), visible emissions are generally present in the flame. When visible emissions become significant, the SI value will climb even higher to a maximum value of 10 for thick black smoke. Testing has shown that SI values above 3.0 may cause a small negative bias on the CE measurement by VISR (< 1%) and SI values above 5 may cause a significant negative bias to CE measured by VISR, as confirmed by testing with an extractive sampling method as a control (note that in the extractive sampling method, carbon soot is not included in the CE calculation). Any data points with a smoke index above 5 were removed from the summary tables and **Appendix A** as they are considered outside of method limits.

Observations

The following sections describe field observations and comparisons derived from the dataset.

Continuous vs non-continuous results

The FlareGuardian typically provides continuous 1-second data recording by applying automated data reduction methods to the streaming multi-spectral radiometric images. However, these data reduction methods were designed to process data from an elevated flare and did not work very well on this enclosed ground flare during the first flare test on January 13th. During the test there were several raw radiometric files captured, which retain all of the radiometric data from the FlareGuardian instrument. These files were then post processed to provide the results in ***Table 1*** and **Appendix A**. Although this does not impact the quality of the data from the first flare test, it does impact the data availability. The first flare test lasted approximately 15 minutes (from instrument in focus to the end of the event). The data processed from the raw radiometric files amounts to about 2 minutes out of the 15 minute test.

After the first test, the algorithms to reduce the radiometric data were adjusted to accommodate the unique signature of an enclosed ground flare. These adjustments performed well for the remainder of the field study. Continuous 1 second data is provided for both the second flare test on January 19th and the flaring event on January 20th.

Methane/Hydrogen test

The Methane/Hydrogen test on January 13th, 2023 did not produce continuous 1 second data. ***Figure 1*** below shows the data in a time series plot with gaps inserted between the discrete data sets. Combustion Efficiency and Destruction Efficiency are plotted on the primary axis,

while Smoke Index and Fractional Heat Release are plotted on the secondary axis. The time stamps for the data for this test should be considered approximate.

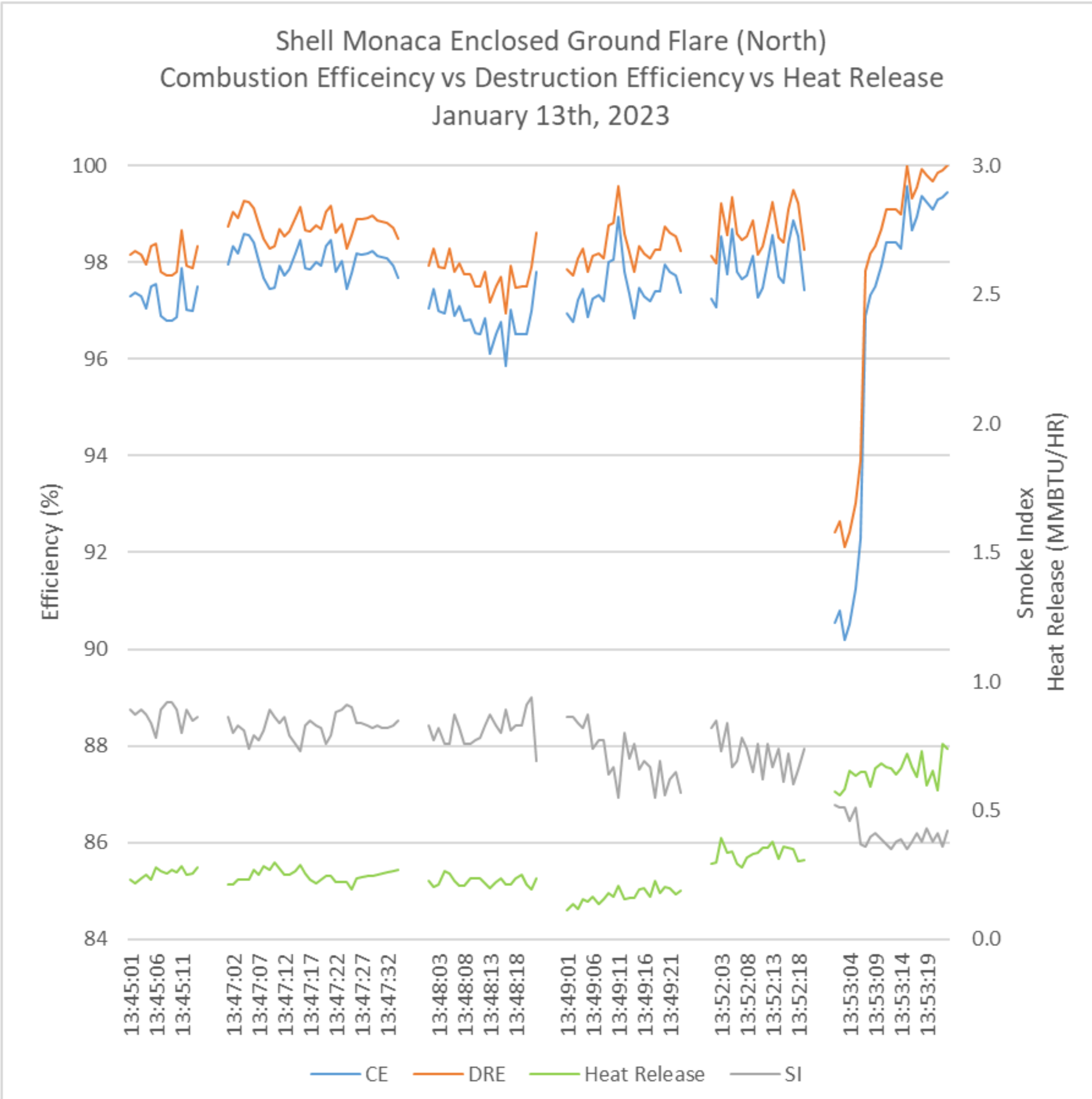

Figure 1: FlareGuardian data for enclosed ground flare on 1/13/2023.

Ethane/Methane Test

The Ethane/Methane test on January 19th, 2023 utilized the improved data reduction algorithm and produced continuous 1 second data. ***Figure 2*** below shows the data in a time series plot for this test point. Combustion Efficiency and Destruction Efficiency are plotted on the primary axis, while Smoke Index and Fractional Heat Release are plotted on the secondary axis.

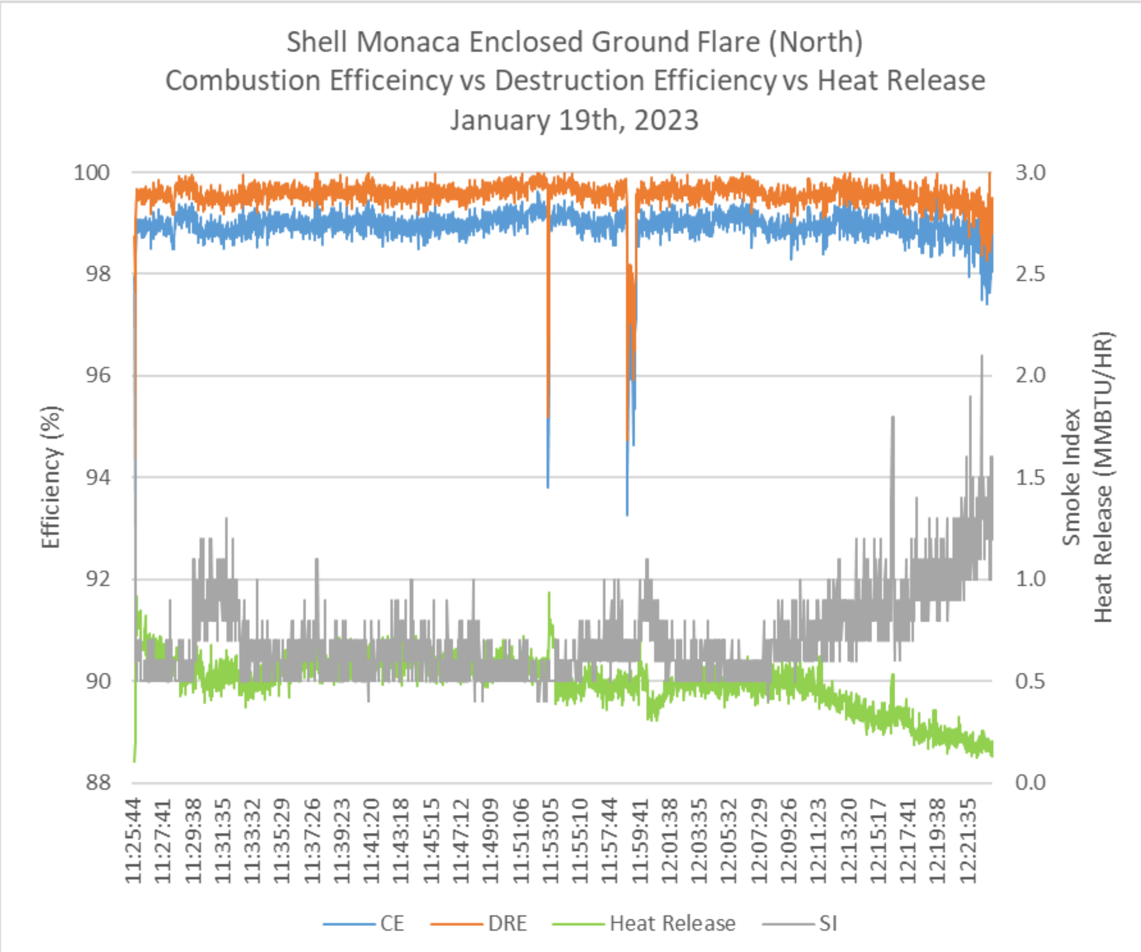

Figure 2: FlareGuardian data for enclosed ground flare on 1/19/2023.

Flaring Event

The flaring event on January 20th, 2023 also produced continuous 1-second data. ***Figure 3*** below shows the time series plot for the flaring event. Combustion Efficiency and Destruction Efficiency are plotted on the primary axis, while Smoke Index and Fractional Heat Release are plotted on the secondary axis.

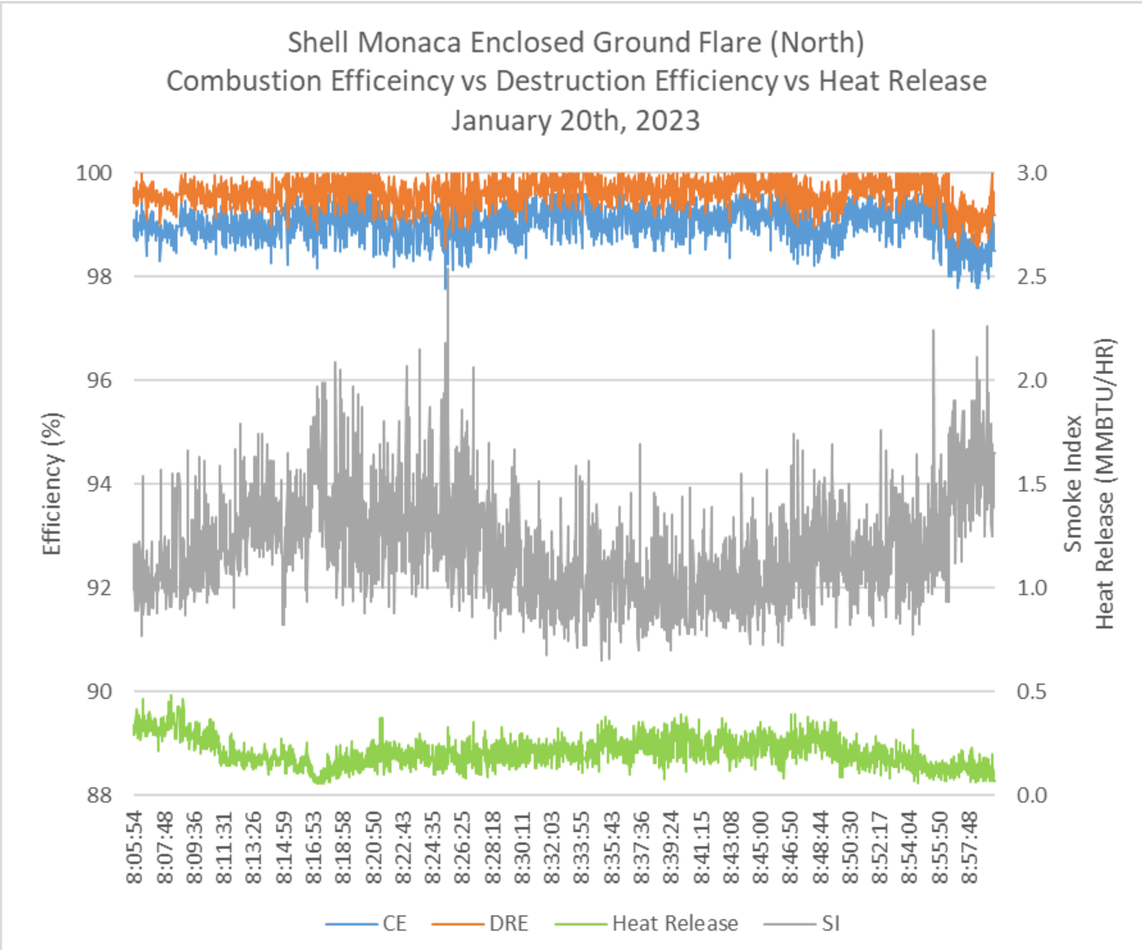

Figure 3: FlareGuardian data for enclosed ground flare on 1/20/2023.

Summary

A FlareGuardian was installed at the Shell Polymer's Monaca (SPM) facility in Beaver County, Pennsylvania on January 12th, 2023. It remained installed and continuously running until it was removed on January 20th, 2023. During the installation, two flare tests and one unscheduled flaring event were recorded by the FlareGuardian. During the first flare test, the automatic data reduction algorithm did not work very well. It was improved and performed well during the second flare test and the flaring event, providing continuous 1-second data for both. Any future tests involving enclosed combustors will benefit from this improvement in the FlareGuardian method.

References

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2. Yousheng Zeng, Jon Morris. (2019, April 2nd). *Precision and Accuracy of the VISR Method for Flare Monitoring*. Air Quality Measurement Methods and Technology, Durham, North Carolina, United States.

Appendix A: Results

Date/Time				Description	Efficiency (%)					Smoke Index (0-10)				Flare Footprint (m^2)				Fractional Heat (MMBTU/HR)			
ID	Date	Start Time (Local)	End Time (Local)	Process Condition	CE Avg	DRE Avg	CE Min	CE Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
1	1/13/2023	1:45 PM	1:53 PM	Flare test - Methane/Hydrogen	97.39	98.24	90.19	99.57	1.58	0.7	0.4	0.9	0.2	187	91.0	289.0	41.6	0.31	0.11	0.76	0.16
2	1/19/2023	11:25 AM	12:23 PM	Flare test - Ethane/Methane	98.93	99.55	92.85	99.69	0.40	0.7	0.4	2.4	0.2	195	79.0	285.0	28.2	0.49	0.11	1.07	0.13
3	1/20/2023	8:03 AM	9:02 AM	Flaring event	99.01	99.62	95.87	99.57	0.32	1.2	0.7	2.5	0.2	150	45.4	299.6	42.5	0.21	0.05	0.48	0.07

Table 2: Complete Mantis Results.

Appendix B: Validation of the VISR method

Precision and Accuracy of the VISR Method for Flare Monitoring

Extended Abstract: ME92
Presented at the conference:
Air Quality Measurement Methods and Technology
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Introduction

Industrial flares represent a large category of air emission sources for Volatile Organic Compounds (VOC), air toxics, and greenhouse gases (GHG)[1-4]. Depending on their combustion efficiency (CE), the emissions of these air pollutants can be significantly different. Despite the large contribution of flares to air emission inventories, flares are the only source category for which no EPA test or monitoring methods can be applied to directly measure their efficiency or emission rates. As a result, flare emissions in air emission inventories may carry significant uncertainties.

A method based on Video Imaging Spectral Radiometry (VISR) has been developed for testing or continuously monitoring combustion efficiency (CE) of industrial flares[5]. To validate the VISR method, tests were conducted at flare test facilities of Zeeco, Inc. (Zeeco) and John Zink Hamworthy Combustion (John Zink), both located in Tulsa, Oklahoma, in September and October 2016, respectively. The test at Zeeco included both an air assisted flare and a steam assisted flare. Twenty-eight flare conditions were tested, 14 for the air flare and 14 for the steam flare. This test is referred to as the "Zeeco Test" in this paper.

The test at John Zink was part of a program sponsored and organized by the Petroleum Environmental Research Forum (PERF), an industry consortium. PERF project 2014-10 Direct Monitoring of Flare Combustion Efficiency was created and funded by participating PERF companies to provide a test platform for various developers/vendors of flare remote sensing technologies (Invitees) to participate in a blind test to evaluate the effectiveness of each technology. The blind test was administered by John Zink. Testing began on October 17th, 2016 and continued for 10 days, concluding on October 27th, 2016. The flare tip used was the John Zink model EEF-QSC-36, which was the same flare tip used during the 2010 TCEQ Flare Study[4]. A test protocol was developed which identified a series of test conditions to evaluate various factors

that could affect flare CE measurement. Only limited logistical and environmental factors were shared with the Invitees (i.e., distance from the flare, view angle with respect to flame orientation due to wind, sun in/out of the field of view, daytime/nighttime testing). Information regarding flare operations such as the type of fuel gas used, firing rates, steam rates or any other flare operating parameters was concealed from Invitees. A total of 45 test points was evaluated over the 10 days of testing. Extractive sampling was performed on each test point as the control method for flare CE measurement. The results of the extractive sampling were not provided to Invitees until Invitees submitted their won results based on their respective measurement technology. This test is referred to as the “PERF Test” in this paper.

In this paper, the precision and accuracy of the VISR method are evaluated based on the test campaigns described above.

Methods and experimental setup

The VISR flare monitor is a remote monitoring device that can be positioned at any distance as long as the flare to be monitored is in the line of sight and there are a sufficient number of pixels of the flare flame image in the VISR monitor. The distances from flare to the VISR monitor in the experiments reported here were in the range of 174 feet to 650 feet. To evaluate the performance of the VISR method, an extractive sampling system was used as a reference method. A sample extraction apparatus was suspended by a crane over the flare plume to extract combustion product gases. The sample was transported through a heated sampling line to a sample manifold in a testing trailer. The sample manifold was connected to analyzers for oxygen (O_2), carbon dioxide (CO_2), carbon monoxide (CO), and hydrocarbon (HC). The methods for measuring O_2, CO_2, CO, and HC were EPA Method 3A, 3A, 10, and 25A, respectively. The level of O_2 was used to confirm that the sampling probe was in the flare plume. The concentrations of CO_2, CO, and HC were used to calculate flare CE per method used in the 2010 TCEQ flare study[3].

These test campaigns covered a wide range of process conditions: two steam flares and one air flare; multiple vent gas compositions (natural gas, propane, propylene, hydrogen, in pure form or mixed with nitrogen; vent gas flow range from 10 lb/hr to 10,000 lb/hr; various steam and air assist levels resulting in combustion zone net heating value (NHVcz) in a range of 120 to 1,250 Btu/scf for the steam flares and net heating value dilution parameter (NHVdil) in a range of 6.7 to 244 Btu/ft^2 for the air flare.

The test campaigns also covered a wide range of environmental conditions: distance ranging from 174 ft. to 650 ft.; different wind speed and direction (crosswind, wind oriented towards VISR device, and wind oriented away from VISR device); daytime vs. nighttime; various sky conditions (blue sky, cloudy, moving clouds); the Sun in or out of field of view; rain, and fog.

Results and Discussions

Precision

Precision is a measure of how the results of multiple measurements by the same method scatter while the target of the measurement holds steady. This is difficult to assess for flare measurements because even when the flare operating conditions are held steady (as they were in each test point of the PERF Test), the flare CE may change due to changes in environmental conditions. Analyte spiking or quadruplet sampling described in EPA Method 301 would help to isolate the measurement method precision from the fluctuation of the target itself[6]. However, these methods are not feasible for flare measurement. Nevertheless, the measurement precision can still be evaluated using the data from the PERF test. For each PERF test condition, 4 segments of measurement were made by the extractive method and 3 segments of measurement were made by VISR while the flare operating conditions were held constant (although flare CE did fluctuate due to changes in environmental conditions). The standard deviation (SD) and relative standard deviation (RSD) can be calculated based on these replicate measurements. **Table 1** is a summary of the SD and RSD for both the VISR method and the extractive method used in the PERF Test. As shown in **Table 1**, the RSD for the VISR method is in a range of 0.07% to 1.98% with an average of 0.62%. The variation of the VISR method appears to be slightly better than the extractive method from the perspective of both the average and the range of the RSD values, suggesting that the precision of VISR is at least as good as the extractive method. Note that in both cases, the variation due to changing environmental conditions is included in the RSD as there is no practical method to separate it. Despite the inclusion of environmental changes, the RSD is more than an order of magnitude smaller than 20% as required in EPA Method 301 (Section 9.0)[6]. If a more stringent criteria is used in which the 20% limit on RSD is applied to the most relevant range of 90-100 % CE measurement (i.e., in the span of 10 % CE measurement), the criteria would be SD < 2 % CE (20% of 10% = 2 % CE). As shown in **Table 1**, the highest SD is 1.84 measured as % CE, which is lower than the SD of 2 % CE measurement and therefore satisfies the more stringent criteria.

Table 1. Relative Standard Deviation (RSD) of VISR and extractive method per PERF Test

Method	CE Avg.	CE Range	SD Avg.	SD Range	RSD Avg.	RSD Range
VISR	96.47	80.61-99.91	0.59	0.07-1.84	0.62%	0.07-1.98%
Extractive	96.41	83.50-100.00	0.83	0.00-2.61	0.88%	0.00-2.72%

The Zeeco Test did not include multiple replicated measurements under each test condition. Therefore, a precision analysis is not performed on that data.

Accuracy

The accuracy of the VISR method is evaluated based on the Zeeco Test and PERF Test. In these two tests, the flare CE was measured by both the VISR method and the extractive method. The extractive method was used as the control (reference) method. Strictly speaking, what can be assessed is the agreement between the two methods, not the accuracy of either method because the true flare CE is unknown. The agreement between the two methods can be evaluated using a statistical method. One such method is to use t-test on the differences between the paired CE measurements by VISR and extractive methods. This method is the same as the method used in EPA Method 301 to determine if there is a difference caused by different sample storage time[6] (it should be noted that the methods for bias described in Method 301 are not directly applicable because they are specifically designed for analyte/isotopic spiking or quadruplet sampling systems, which are not feasible for flare measurement). The value of the t-statistic is calculated using the following equation.

$$t = \frac{|d_m|}{\frac{SD_d}{\sqrt{n}}}$$

Where d_m and SD_d are the mean and the standard deviation of the difference of the paired samples (VISR and extractive sample), and n is the total number of samples. The resulted t-statistic value is compared to the critical value of the t-statistic with a 95 percent confidence level and n-1 degree of freedom. If the resulted t-statistic value is less than the critical value, the difference between the VISR method and the extractive method is not statistically significant, i.e., the two methods are statistically the same. The results of the t-statistical analysis for both Zeeco and PERF tests are summarized in **Table 2**. The number of samples (tests) in **Table 2** is less than the number of tests actually conducted because some tests were designed for other purposes (e.g., smoke test) and they are not included in the evaluation of the agreement between VISR and extractive methods.

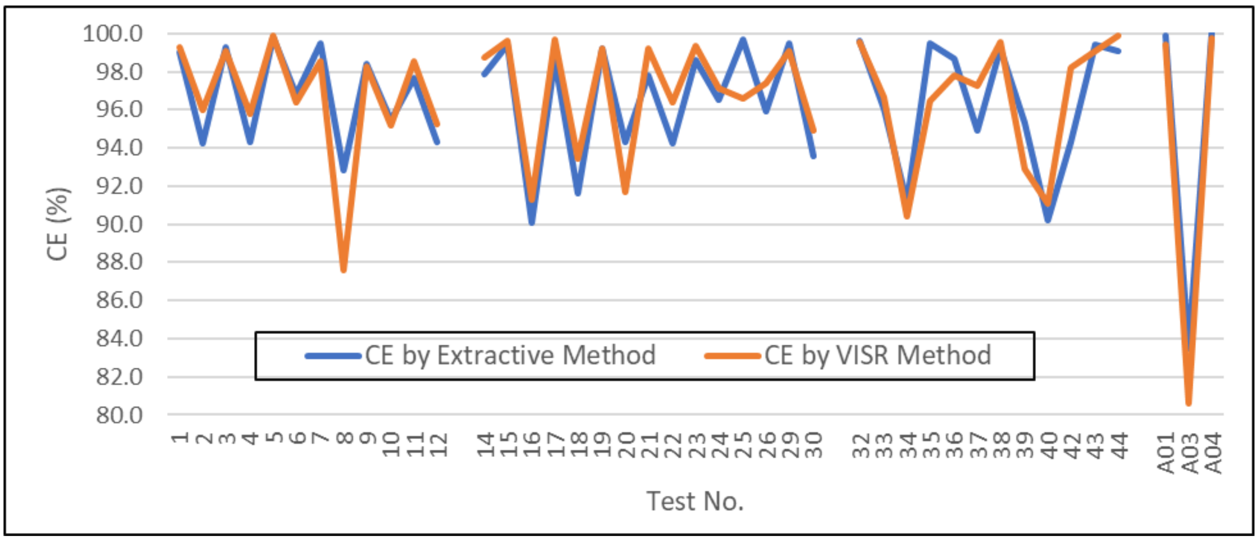
Table 2. t-Test to determine if the VISR method is different from the extractive method

	Zeeco Test (Steam Flare)	Zeeco Test (Air Flare)	PERF Test
No. of Samples, n	11	9	42
Mean Difference, d_m (% CE)	0.30	-0.21	0.07

Standard Deviation, SD_d (% CE)	1.32	0.65	1.69
t-Statistic Value	0.756	0.967	0.254
Degree of Freedom	10	8	41
t_95 Critical Value	2.228	2.306	2.020
Statistically Different?	No	No	No

As demonstrated in **Table 2**, statistically there is no difference between the flare CE measured by the VISR method and by the extractive method. The agreement between the two measurement methods can also be illustrated in **Figure 1** using the results from the PERF Test.

Figure 1. Flare CE measured by VISR method and extractive method – PERF Test results



Conclusion

Industrial flares can now be measured or continuously monitored by the VISR method for their performance, i.e., combustion efficiency (CE). The VISR method is a remote sensing method and can be deployed easily and practically. The VISR method transforms flare testing/monitoring from most difficult task (impossible in many cases) to a task that is easier than most conventional air emission testing methods. With the significant potential benefits that the VISR method can bring, it is important to characterize and understand the precision and accuracy of this method.

Through a large number of tests under various process and environmental conditions, a high precision and accuracy have been demonstrated for the VISR method. The relative standard deviation (RSD) is in the range of 0.07-1.98% with an average RSD of 0.62% for flare CE in the range from 80 to 100%. The average RSD of 0.62% is more than an order of magnitude smaller than the minimum precision target of 20% RSD set in EPA Method 301. The highest SD is only 1.84 measured as % CE.

The flare CE measured by the VISR method is in excellent agreement with the flare CE measured by the extractive method. The mean difference between the two methods is in the range of -0.21 to 0.30 measured in % CE. The t-statistic value in each of the three test groups are well below its corresponding t-test critical value, passing the t-test with a substantial margin. Keep in mind that the extractive method is suitable only in research. It is virtually impossible to deploy the extractive method to elevated flares at industrial production facilities. Having a method that can be easily deployed to industrial sites and produce highly time-resolved and accurate flare measurement results is a significant advancement.

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Appendix C: Combustion Efficiency Versus Destruction Efficiency

With respect to emissions calculations or GHG reporting, it is important to consider the difference between combustion efficiency (CE) and destruction efficiency (DE). The VISR method measures CE, which is a measure of the efficiency of the flame to convert hydrocarbons into carbon dioxide and water. If the combustion efficiency is 100%, then all of the hydrocarbons have been oxidized all the way to carbon dioxide, leaving no hydrocarbons in the post combustion plume. CE will be reduced as the percentage of hydrocarbon in the post combustion plume increases. Destruction efficiency is a measure of the percentage of a compound that is destroyed (IE converted into another form), but not necessarily oxidized to the ultimate combustion product of carbon dioxide and water. In this case, it represents the percentage of hydrocarbons destroyed. The hydrocarbons could be converted to carbon dioxide, carbon monoxide, soot or another compound. As a result, DE is typically higher than CE. For emission inventory purposes, flares are generally deemed to have a DE of 98%, meaning 98% of the hydrocarbons sent to the flare are converted into another form. There is no quantitative method to convert the VISR CE data to DE, however we do have some points of reference. The US EPA Refinery Sector Rule (40 CFR 63.670 (r) equates a CE of 96.5% to a DE of 98%. The rule references the John Zink combustion handbook (Baukal, 2001).

In addition, there have been two major studies which have measured both CE and DE with extractive sampling: the 2010 TCEQ Study and the 2016 PERF Study. Both of these studies were conducted at John Zink's research facility in Tulsa, Oklahoma. Taken collectively, these studies provide 71 individual measurements of CE and DE. *Figure 8* below shows the relationship between CE and DE from these two studies.

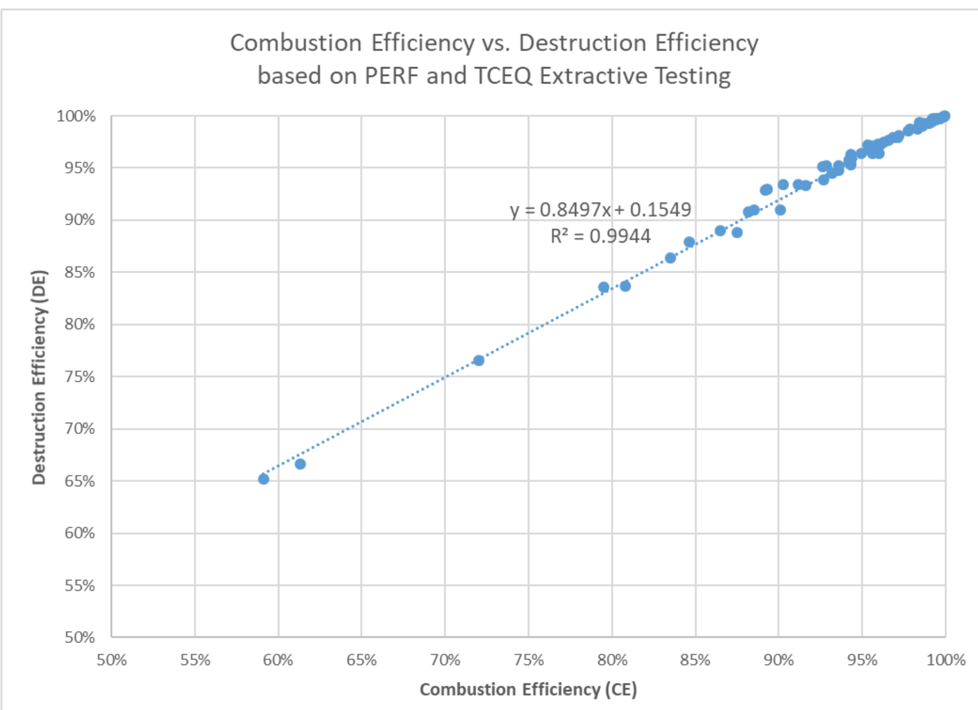

Figure 17. CE vs DE from extractive sampling during PERF and VISR studies.

As demonstrated by the chart, the relationship between DE and CE is quite linear. The fit equation to this data has an R^2 of 0.99. Equation 2 below can be used to convert CE to DE using this correlation:

$$DE\ (\%) = CE\ (\%) * 0.8497 + 0.1549$$

Equation 2

It should be noted that when SI is high and CE appears to be low, the destruction efficiency (DE) may still be high as the hydrocarbons are combusted into soot instead of oxidizing to the ultimate combustion products of water and CO_2. The CE-DE relationship shown in *Figure 8* is established under no smoke conditions. There has not been sufficient study on a similar CE-DE relationship when there is significant smoke in the flare. This equation will be valid for CE within a range of 60% to 99.4%. Above 99.4%, the DE will be capped at 100%. Below 60%, there is no extractive data available to extend the correlation.